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Spacecraft Thermal Blanket Cleaning: Vacuum Bake or Gaseous Flow Purging

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PREFACE

The mass losses and the outgassing rates per unit area of three thermal blankets consisting of various combinations of Mylar and Kapton, with interposed Dacron nets, have been measured with a microbalance using two methods. The blankets at 25°C were either outgassed in vacuum for 20 hours, or were purged with a dry nitrogen flow of 3 cu. ft. per hour at 25°C for 20 hours. The two methods have been compared for their effectiveness in cleaning the blankets for their use in space applications. The measurements were carried out using blanket strips and rolled-up blanket samples fitting the microbalance cylindrical plenum. Also, temperature scanning tests were carried out to indicate the optimum temperature for purging and vacuum cleaning. The data indicate that the purging for 20 hours with the above N₂ flow can accomplish the same level of cleaning provided by the vacuum with the blankets at 25°C for 20 hours. In both cases, the rate of outgassing after 20 hours is reduced by 3 orders of magnitude, and the weight losses are in the range of 10E-4 gr/cm². Equivalent mass loss time constants, regained mass in air as a function of time, and other parameters were obtained for those blankets.

INTRODUCTION

Thermal blankets are used to protect surfaces of spacecraft and space instruments and to provide thermal control of the system they are covering. The blankets consist of layers of materials having highly reflective surfaces interposed by dacron nets. The outer layers are, for protective reasons, thicker than the others and have surface coatings designed to reflect specific radiation wavelengths. These blankets are required to protect a satellite against electrons, protons, and ultraviolet radiation, and to be stable in the

presence of atomic oxygen, moisture, and radiation. Materials used for these blankets are Kapton and Mylar which may be surface aluminized or gold coated. The primary function of thermal protection is accomplished by the evacuation of the space between the layers. The evacuation eliminates thermal conductance of the gases between the layers. The elimination of gas conductance requires the pressures between the layers to be on the order of 10⁻⁵ to 10⁻⁶ torr.

At those pressures, the mean free paths of the residual gases are considerably larger than the interspace between layers. The evacuation to these low pressures requires the venting of the gases via perforations in the blanket and/or the blanket edges. In edge venting, the initial gas evacuation occurs in the continuous, gaseous flow regime. This evacuation occurs quite rapidly, depending on the dimensions of the blanket and the size of the vent openings. After this initial evacuation, the flow changes first to the transitional flow regime and then to the molecular flow regime when the molecules randomly move and find the exit vents. The escape of these residual molecules, which is needed to bring about the required drop in gaseous thermal conductance, is very slow. It involves the release of molecules held on the material's surface, of molecules produced by degradation of the material, and of molecules diffused out of the material. This process is quite slow and requires extended vacuum pumping. The molecules which are released and removed from the blankets are mainly H₂O, N₂, CO₂, rare gases, and others originating from the environment. These are held on the surface by physical adsorption forces or they are chemically adsorbed and require different levels of energy for their removal. The molecules are attracted to the surface and held mainly by polar van der Waals forces. At equilibrium, a balance results between the molecules from the environment arriving on the surface and those leaving the surface. However, the concentration of

molecules on the surface will eventually be greater than that of the ambient. The energies required for their removal vary from about 6 kJ/mole for H, 13-17 for Ar, O, N, CO₂ and 40-60 kJ/mole for long chain molecules. The water molecules, which may be the major constituent are chemisorbed on the surface and require about 40 kJ/mole (9.56 kcal/mole). The surface-molecules can be removed by pumping, creating a difference of molecular concentration between those on the surface and the ambient, by a scrubbing flow of purging gases, or by imparting thermal energy to the surface molecules. Concurrent with the removal of surface molecules, there may be releases by diffusion of decomposition products consisting of unreacted molecules and other molecular fragments. The molecular removal, which can be described as an initial surface degassing followed by, or in conjunction with, an internal outgassing, decreases slowly with time. It involves simultaneous processes and can be represented, in general, by an inverse function of time to a power (0.5 to 2) reflecting the combination of those removal processes.

For the blankets to become effective thermal protectors in a reasonable time following launch, the blankets are cleaned by baking in vacuum chambers. The cleaning of the blankets in vacuum, referred to as blanket bake-out, is quite expensive since it involves considerable time and expense for the preparation of the vacuum chamber, the installation, the instrumentation, and the actual vacuum bake of the blanket. It may introduce scheduling conflicts for the use of a limited number of available vacuum chambers.

The present investigation explores the effectiveness of using a purging flow of clean nitrogen gas through the blanket interfaces in a container at ambient pressure, in place of the vacuum bake cleaning of the blanket. The purge is intended to provide a mechanical scrubbing of the surfaces, a gradient of concentration between the molecules on the surfaces and the purging gas, which provides partial pressure differences sufficient to remove the surface molecules and carry them away. Also, purging with the gas at elevated temperatures can provide sufficient activation energy and a rapid removal of those molecules which would be expected to outgas, in flight. The purging method can be less costly, be performed without interference with other tests requiring vacuum chambers, and can be carried out very near the launch time.

The cleaning of the blankets has important benefits. It reduces the number of molecules originating from the blanket outgassing, which in space, can deposit and contaminate adjacent contaminationcritical surfaces such as cryogenic surfaces, mirrors, lenses, and other thermally controlled surfaces. It reduces the gaseous cloud of outgassed molecules which forms about a spacecraft in orbit and impairs optical observations. Also, cleaning the blanket before its application reduces the length of time required for the testing of the complete spacecraft in a vacuum chamber and eliminates possible contamination produced by the blanket outgassing.

In the context of this investigation, data on the outgassing behavior of blanket materials (Mylar, Kapton, Dacron net, Fibercloth) are reported in References 1, 2, 3 and 4. Glassford, in Ref. 1, was interested in the behavior of thermal blankets used to insulate cryogenic fuel tanks. His tests showed that by purging for 30 minutes at 100°C with N₂ or He, the outgassing rate at 25°C of plain, double-aluminized Mylar would drop one to two orders of magnitude. The purging at 25°C had a negligible effect on the outgassing rate. He also showed that prepumping the Mylar for 30 minutes, exposing it to 1 atmosphere of pressure and 35 percent RH of room air for 1 day, and then evacuating at 25°C, provided no improvement of the outgassing over that obtained for "as received" conditions. However, if the prepumped Mylar was brought back to 1 atmosphere using He, then exposed to ambient pressure (35 percent RH) either for 5 or 31 days and then repumped, the outgassing rate of that Mylar was reduced by a factor of about 3 over the "as received" Mylar. This, according to Ref. 1, suggested that prepumping is an effective form of preconditioning, at least for short periods, if the sample is brought back to 1 atmosphere with He.

TESTS

The tests for the comparison of the purge method and the vacuum bake method were both carried out at a temperature of 25°C in the same vessel. The tests consisted of measuring the blanket weight losses as a function of time. The blanket samples were exposed to the same environment of about 20°C, 50 percent RH for an unknown but long period of time before the tests. The tests in each case were arbitrarily carried out for 20 hours. However, the change in masses were no longer

measurable with the gravimetric instrumentation used for the tests after 20 hours of testing. All weight loss tests were carried out in the vessel equipped with an Ainsworth microbalance. The holding arrangement in the vessel is shown in Figure 1.

The following tests on three different types of thermal blankets were carried out:

- (a) Measurement of the weight loss versus time of each of the three blankets held at 25°C as a function of time while in a vacuum of 10^{-6} torr for a period of 20 hours.
- (b) Measurement of the weight loss versus time of each of the three blankets while being purged with 3 ft³/hr of dry nitrogen at 25°C for 20 hours. The purge rate provided a volume change of about 24 changes per hour.
- (c) Measurement of the weight loss of each sample as a function of time during an initial 6 hours of purging followed by an additional 14 hours under vacuum using the same pressures, temperatures, and flow rates indicated for tests (a) and (b). The changeover from purging to vacuum baking at 6 hours was based on the flattening of the curve showing mass loss versus time. The same reasoning was followed in stopping the test at 20 hours.
- (d) Measurement of the weight loss rates in vacuum while changing the blanket's temperature, or changing the purging temperatures while the blankets were being purged. In these tests, designed to determine the most effective purging and blanket temperatures, the temperatures were chosen so as not to exceed safe blanket and spacecraft temperatures.
- (e) Measurement of the weight gain of a previously cleaned blanket sample as a function of time while exposed to a normal 25°C, 50 percent RH.
- (f) Measurement of the total mass loss (TML), condensable volatile collected mass (CVC) and water vapor regain (WVR) on a sample of assembled blanket and on the individual constituents of the blanket using the ASTM-E-595 test for outgassing of materials.

The Thermal Blankets and Testing Apparatus

The thermal blankets tested for weight losses were designated by type numbers I, II, and III. The blankets were assembled from aluminized Mylar and aluminized Kapton supplied by the following companies: Metallized Products, MA; Sharr Industries, CT; Dunmore Corporation, PA; and Sheldahl Corporation, MN. The Dacron netting was supplied by Apex Mills, NY. The three tested samples, 6 inches long and 6 inches wide, were rolled into cylindrical shapes of approximately 1 inch in diameter and secured at both ends with chromel wires. The rolling of the blankets provided additional blanket surface areas within the confines of the 3-inch-diameter cylindrical measuring instrument vessel. Figure 2 shows one of the rolled samples. Tests were also carried out with unrolled samples for Type II and Type III blankets. Figure 3 shows one of the unrolled samples, 6 inches long by 1.5 inches wide. The samples under test were suspended on a stainless steel rod attached to the Ainsworth microbalance. The blanket samples, sketched in Table I, consisted of the following:

Blanket Type I

Of the two outermost materials, one consisted of 3-mil Mylar with the interior face of the blanket aluminized. The other outermost material consisted of 1-mil Mylar aluminized, as the other, on the surface facing the interior of the blanket. In between, both included 10 layers of 0.25-mil Mylar aluminized on both sides and 11 layers of Dacron netting sandwiched between each layer.

Blanket Type II

Both the top and bottom layers of material consisted of 3-mil Kapton with the exterior faces aluminized. They included 12 layers of 1/3-mil Kapton aluminized on both faces, and 13 layers of Dacron netting.

Blanket Type III

One of the outer materials was 3-mil Mylar aluminized on both sides. The other outer layer was made of 3-mil Kapton but with an aluminized interior-facing surface. They included 18 layers of 0.25-mil aluminized Mylar on both sides, and 19 layers of Dacron netting.

The weight loss measurements in vacuum and at atmospheric conditions under N₂ purging were carried out using an Ainsworth Recording Vacuum balance. The balance has a capacity of 100 grams, has a sensitivity of 0.1 mg and a Bristol strip chart readability level of 0.1 mg. The specimen weight loss is automatically recorded on the strip chart which also records the temperature. The temperature of the specimen can be varied in increments of 5°C. The vacuum chamber in which the sample is inserted and heated, is a 20-inch-long quartz tube 3 inches in diameter. The vessel shown in the sketch (Figure 1) is evacuated with a 6-inch diffusion pump with an LN₂ trap backed by a roughing pump. A cylindrical 10-inch O.D., 10-inch-long electrical resistance heater provided radiative heating to the blanket, if desired. The initial operation consisted of weighing the samples before inserting them in the balance and using that weight as the initial starting point on the recorder.

TEST RESULTS

Figure 4 compares the weight loss for the three blankets while in vacuum and while under purging conditions. For both procedures, the test was run for 20 hours at a temperature of 25°C. The open, single-face surface area of the rolled blankets was 36 in² (232.25 cm²) and that of the unrolled blankets was 9 in² (58.06 cm²). For the rolled blankets, the tests show that the weight losses after 20 hours are, for all practical purposes, equal for both vacuum and purging. The total percentage weight loss for Blanket I is about 0.17, while for Blanket II (consisting of external and internal layers of Kapton) the percentage is about 0.56. The weight loss percentage of Blanket III (consisting of a large number of layers and with one face made of Kapton) was about 0.3.

The following results indicated in Table I were derived from the test data shown in Figure 4. Blanket III weight losses per unit area were 1.62×10^{-4} g/cm² when exposed to vacuum at 25°C for 20 hours, and 1.54×10^{-4} g/cm² when purged with 25°C dry nitrogen for 20 hours. The mass losses per unit area of Blanket II were 2.69×10^{-4} g/cm² for both vacuum and purging tests. For Blanket I, the mass loss for the vacuum test was 5.5×10^{-5} g/cm² and for purging, the loss was 5.9×10^{-5} g/cm². As shown in Figure 4, the weight losses plot as exponential functions of time which reflect first-order reaction rates. Based on those plots, an approximate evaluation of the length of time for the weight losses to

reach about 64 percent; i.e. $(1-1/e)$, of the asymptotic final weight loss indicates that for the vacuum tests the time was 2.4 hours for Blanket III, 3.8 hours for Blanket II, and 1.6 for Blanket I. The corresponding times for the purging tests were 3 hours, 6.3 hours, and 2.0 hours.

The test on purging and vacuum cleaning of unrolled blanket strips reproducing more closely the blankets' applications again showed limited differences between purging and vacuum cleaning. The mass losses per unit area for the Blanket III strip were 2.06×10^{-4} g/cm² for both vacuum and purging tests. The time constants were 2.4 hours for vacuum and 1.6 hours for purging. The shorter time to accomplish the 64 percent weight loss under purging compared to vacuum baking is also experienced with Blanket II. The purging time constant was 3.4 hours and the vacuum baking time constant was 4.5 hours. The mass losses per unit area for this blanket were 2.06×10^{-4} g/cm² for vacuum baking and 2.58×10^{-4} g/cm² for purging.

The following figures show the outgassing rates of the three blankets as obtained from the weight losses shown in Figure 4.

Figure 5 shows the outgassing rates for Blanket I in mg/hr or in g/s cm² when the surface area is included in the evaluation. The vacuum outgassing rate is greater than that produced by the purging for about 2 to 3 hours of the initial cleaning period, after which the purging rate is higher. Both curves indicate a rapid change in slope about 7 hours into the test, indicating depletion of the outgassing.

Figure 6 shows the outgassing rates of Blanket II. The crossover where the purge provides a higher rate than the vacuum bake occurs at about 6 hours, and the depletion of outgassing and the corresponding slope change occurs at about 14 to 15 hours.

Figure 7, showing the Blanket III outgassing rates indicates a crossover at about 6 to 7 hours and the depletion between 10 and 12 hours.

The outgassing rates for the strips are shown in Figures 8 and 9. The purging mass loss rates are slightly higher than those from vacuum baking, which reflect the test measurements. Rapid depletion occurs at about 8 to 9 hours in both vacuum and purge tests. Further tests were carried out to validate the previous results.

Figure 10, plotting the weight loss versus time and the corresponding outgassing rate shown in Figure 11, shows the results of using an initial 6 hours' purging followed by vacuum for a total of 20 hours. It is noted that, within experimental limits, the mass losses are the same as those obtained by independently employing either vacuum or purging for 20 hours.

As an attempt to identify the outgassing sources from the blankets and to note the temperatures either during vacuum or during the purging when maximum rates of cleaning can occur, tests were carried out on each blanket type to measure the rate as a function of temperature. In these tests the temperature was increased at a rate of 1°C/minute, and the corresponding change in mass loss was measured. Both temperature and mass loss were recorded simultaneously by the Ainsworth microbalance recorder.

Figure 12 shows the loss rates as a function of temperature recorded during the vacuum cleaning. It shows that Blanket I (with all Mylar layers) has a maximum outgassing rate at about 45-50°C followed by another maximum at about 180°C. Blanket II (with Kapton layers) has a maximum at about 110°C with both lower rates on each side of 110°C. Blanket III (all Mylar with an outer Kapton layer) shows a maximum at about 50°C. Superposed on the same plot, the rate versus temperature produced by the netting alone is shown. The plot shows a maximum for the Dacron net at about 30°C and an apparent increase starting at about 180°C. The increased rates after 180°C may indicate material degradation.

Figure 13 shows the outgassing rates versus temperature, while changing the purging gas temperature. The plots reproduce, as can be seen, the indications provided during the temperature scan for the vacuum cleaning. From these it appears that Kapton (Blanket II) released a large quantity of material, probably water, at 100-110°C. The other two blankets (using mostly Mylar) reach a maximum outgassing rate at about 40-50°C and the outgassing material at those temperatures originates from the netting. Tests on the temperature scans of Mylar and Kapton by themselves were not carried out because the microbalance was no longer available for our use.

Figure 14 shows the percent of weight regained as a function of time by Blanket III as a system and by the Kapton and Mylar material components. These were

exposed to room conditions of 20°C, and 51 percent relative humidity (RH) after they had been baked at 125°C for 24 hours in a vacuum of 10^{-6} torr. The percent of Total Mass Loss (TML) and the Collected Volatile Condensable Materials (CVCM) on a 25°C collector indicated by that test which conforms to the ASTM E-595 test for space applications acceptability of materials, are indicated in this figure. Those results show that the outgassing is mostly water, as is also indicated by Reference 1 (>98 percent water vapor).

RESULTS AND CONCLUSIONS

- Purging can accomplish the cleaning of blankets to a level equivalent to that of a vacuum when both the purging and the vacuum cleaning are carried out for about 20 hours at 25°C.
- Tests of both procedures show that the rates of outgassing are approximately the same using either method of cleaning.
- Both methods reduce the outgassing rates by about 3 orders of magnitude after 20 hours.
- The weight loss per unit area of Blanket II (made up of outer and inner layers of Kapton) was an average of 2.5×10^{-4} g/cm² for the 20-hour, 25°C tests. Blanket III, with one outer layer of Kapton and all the others of Mylar, produced an average loss of 1.82×10^{-4} g/cm². The smallest weight loss of 5.7×10^{-5} g/cm² was produced by Blanket I, made entirely of Mylar. These values are the average obtained combining the measurements of vacuum and purging tests. The differences in weight losses between vacuum and purging tests were ± 7 percent for the rolled blankets.
- The time constants for the rolled blankets varied from about 1.6 hours for Blanket I to 3.8 hours for Blanket II in vacuum, and for the purging from 2 hours for Blanket I to about 6 hours for Blanket II. These longer times for purging than for vacuum must reflect the difficulty of the purge gas to enter the rolled blankets and to dislodge molecules within the blanket layers.

- For the unrolled blankets, the weight losses from purging were slightly larger than from vacuum, about 1 percent for Blanket III and close to 25 percent for Blanket II. The larger percentage may reflect the nature of the many Kapton surfaces making up that blanket. The time constants of these strips, reflecting the freer exposure of the surfaces to the purge gas were shorter for purging than for the vacuum; 1.6 hours versus 2.4 hours for Blanket III and 3.4 hours versus 4.5 hours for Blanket II.
 - The vacuum cleaning for the rolled blankets provides a larger rate of cleaning during the first 2 to 3 hours than the purge cleaning provides. After that initial period, the purging provides slightly higher cleaning rates. As a result, the two methods are equivalent. On the other hand, for the strip of unrolled blanket, the purge cleaning appears to provide a larger rate of cleaning than the vacuum cleaning does. For Blanket Strip III, the initial rate of cleaning for the purge was larger than that for the vacuum. The results for Blanket II indicate a slightly better cleaning from purging than from vacuum throughout the test.
 - The rate of outgassing during the initial 8 to 9 hours represents a removal of molecules from the surface. This process is followed by a rapid depletion of the degassing source. That lower outgassing may represent a diffusion process of molecules out of the material.
 - The maximum rate of outgassing is shown to occur at about 40 to 50°C for Blankets I and III, made mostly of Mylar and netting. This reflects the maximum outgassing of the net at about 40°C.
 - The maximum rate of outgassing for Blanket II occurs near 100°C, showing that the most probable outgassing source is water.
 - The outgassing of the Types I and III Mylar blankets can be more effectively and more rapidly outgassed in vacuum, or under purging at a temperature of 40 to 50°C. These temperatures may be tolerable to the blankets and other nearby systems.
 - The blankets can be degassed by purging with dry nitrogen at temperatures which are acceptable for vacuum bake.
 - The purging should be carried out for at least 10 to 15 hours. After this time, the degassing drops rapidly. For that length of time, both purging and vacuum accomplish a blanket degassing rate reduction of more than 2 orders of magnitude.
 - Stopping purging and allowing the blanket to be exposed to a normal environment of 25°C-50 percent RH results on the reacquisition of moisture on the blanket. Measurements show that, after about 2 days, the blankets would reacquire almost all the mass released in 24 hours at 125°C.
 - Blanket venting at the edges assists the degassing. A flow of 3 ft³/hr appears sufficient for purging.
 - Purging with a gas at temperatures higher than 25°C expedites, and is more efficient in the degassing of thermal blankets.
- In conclusion, purging at normal pressure and temperature for up to 20 hours is equivalent to vacuum degassing at the same temperature and time. Purging can be much more economical, eliminating vacuum chamber preparation, blanket installation, chamber instrumentation, and vacuum chamber scheduling.

ACKNOWLEDGMENT

The author wishes to thank Mr. R. Hunkeler who carried out the various tests, prepared the samples, recorded the data, and maintained the instrumentation for the test.

REFERENCES

1. Glassford, A. P. M., "Outgassing Behavior of Multilayer Insulation Materials," *Journal of Spacecraft and Rockets*, Vol. 7, No. 12, p. 1464, December 1970.

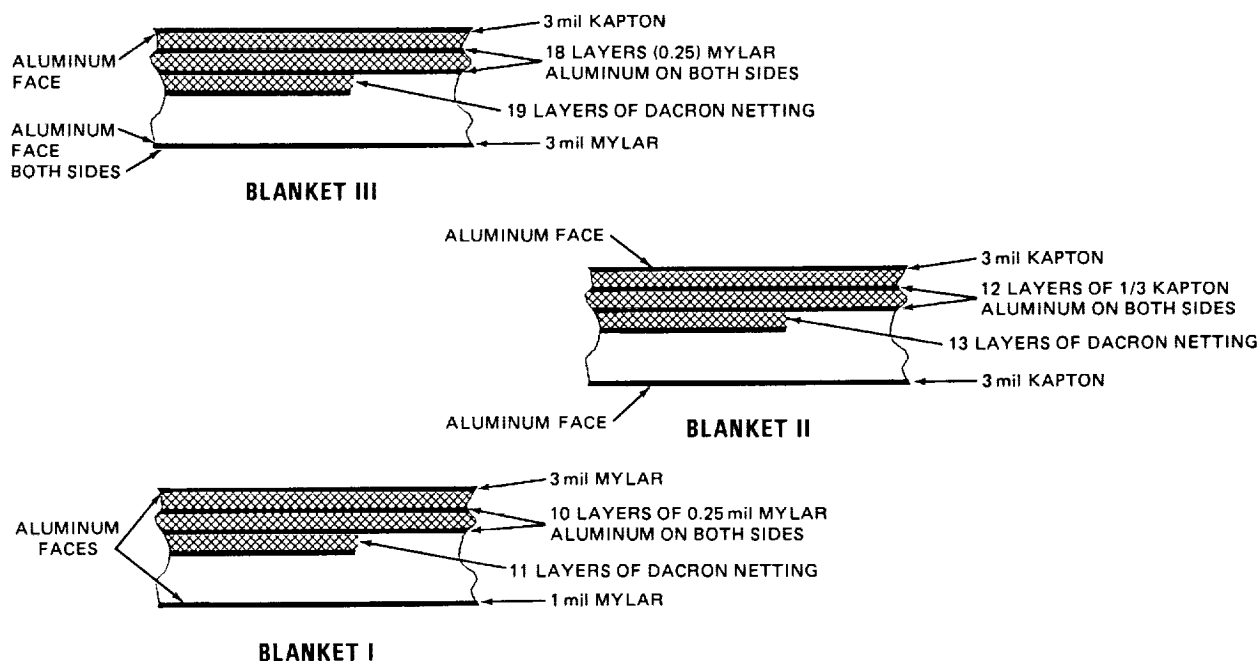
2. Glassford, A. P. M. and C. K. Liu, "Outgassing Rate of Multilayer Insulation Materials at Ambient Temperature," *Journal of Vacuum and Technology*, Vol. 17, No. 3, May/June 1980.
3. Glassford, A. P. M. and C. K. Liu, "Outgassing Rate of Multilayer Insulation," in *Proc. of USAF/NASA International Spacecraft Contamination Conference*, AFML-TR-78-190/NASA CP-2039, J. M. Jemiola, Ed., p. 83, March 1978.
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Table I
Weight Losses per Unit Area and Time Constants of Thermal Blankets

	Rolled Blanket ⁽³⁾		Unrolled (Strip) Blanket ⁽⁴⁾	
	Vacuum ⁽¹⁾	Purging ⁽²⁾	Vacuum ⁽¹⁾	Purging ⁽²⁾
Weight Loss/Unit Area (g/cm²)				
Blanket III	1.62×10^{-4}	1.54×10^{-4}	2.06×10^{-4}	2.08×10^{-4}
Blanket II	2.69×10^{-4}	2.69×10^{-4}	2.06×10^{-4}	2.58×10^{-4}
Blanket I	5.5×10^{-5}	5.95×10^{-5}		
Time Constant (hrs)				
Blanket III	2.4	3	2.4	1.6
Blanket II	3.8	6.3	4.5	3.4
Blanket I	1.6	2.0		

NOTE: (1) Vacuum Degassing for 20 hours @ 10^{-5} torr: blankets @ 25°C
(2) Purge Cleaning with N₂ @ 25°C for 20 hours
(3) Blanket 6" x 6" rolled into a 1" diameter cylinder
(4) Blanket 6" x 1.5" unrolled strip

BLANKETS COMPOSITIONS



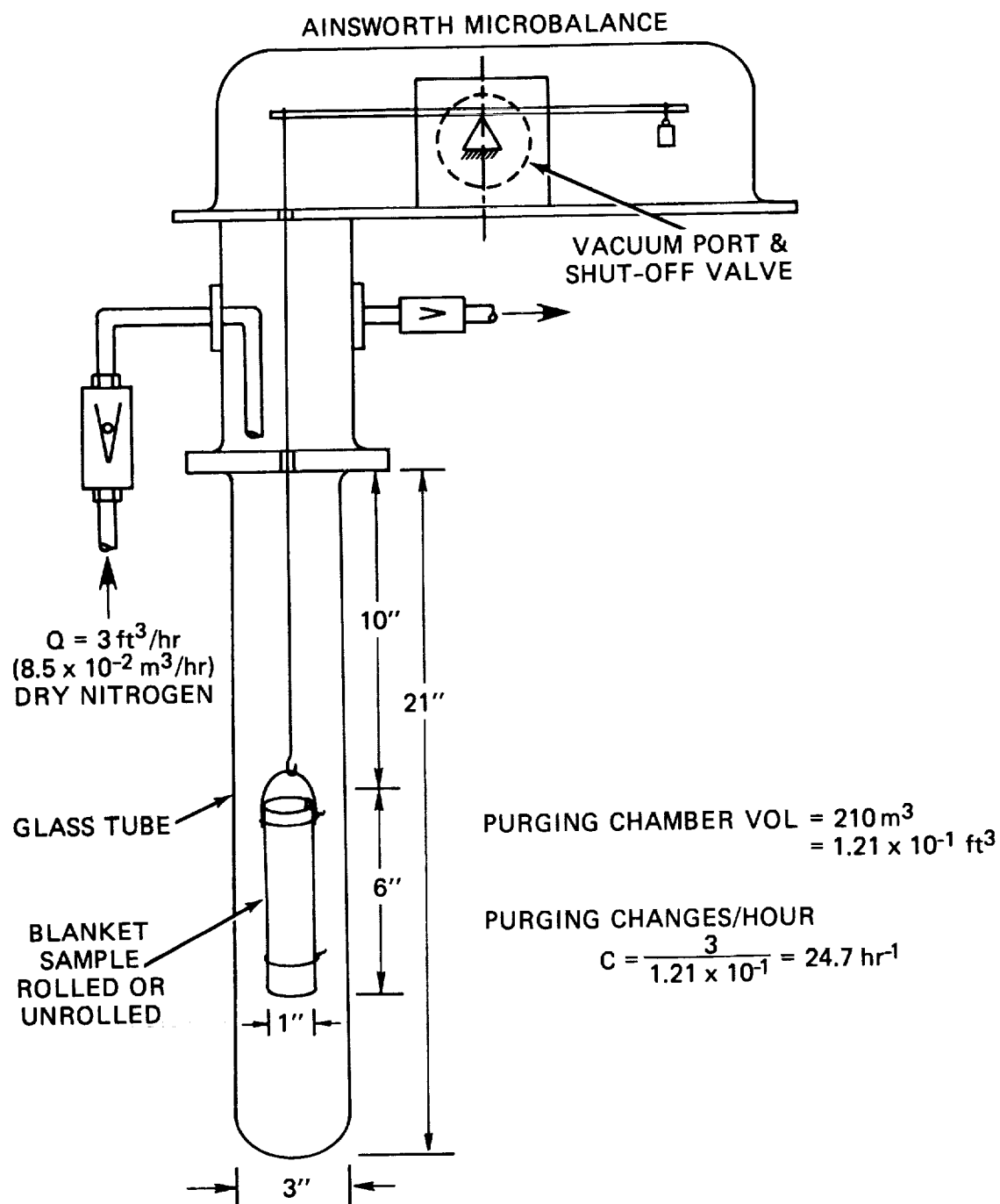


Figure 1. Sketch of Part of the Ainsworth Microbalance, Showing Sample Attachment, Vessel and Purge Set-Up.

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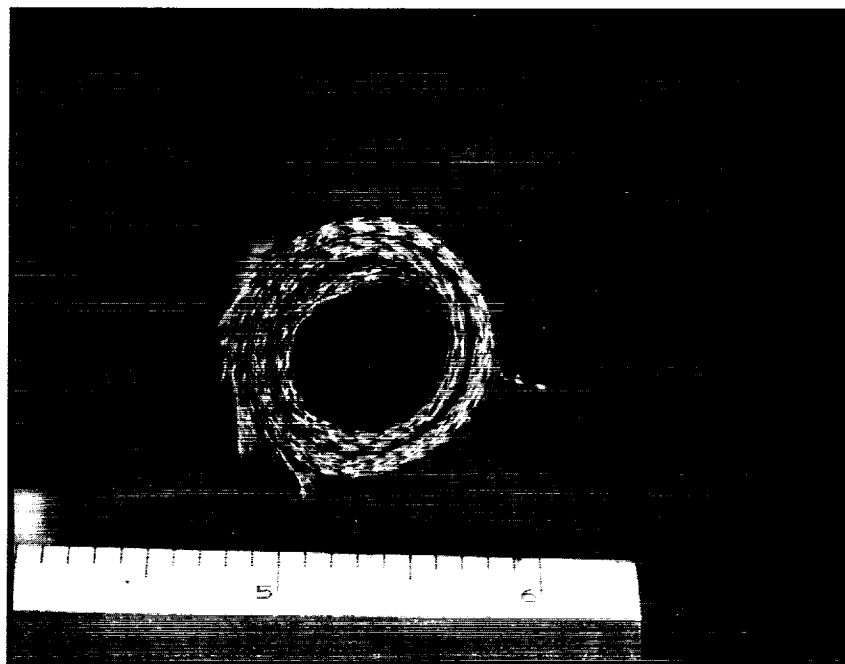
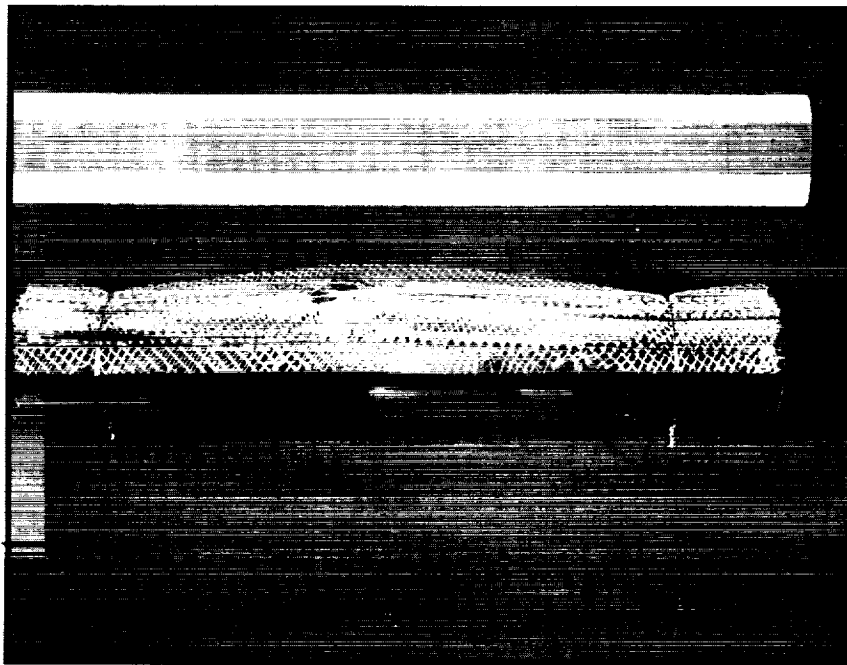


Figure 2. Rolled Blanket Sample

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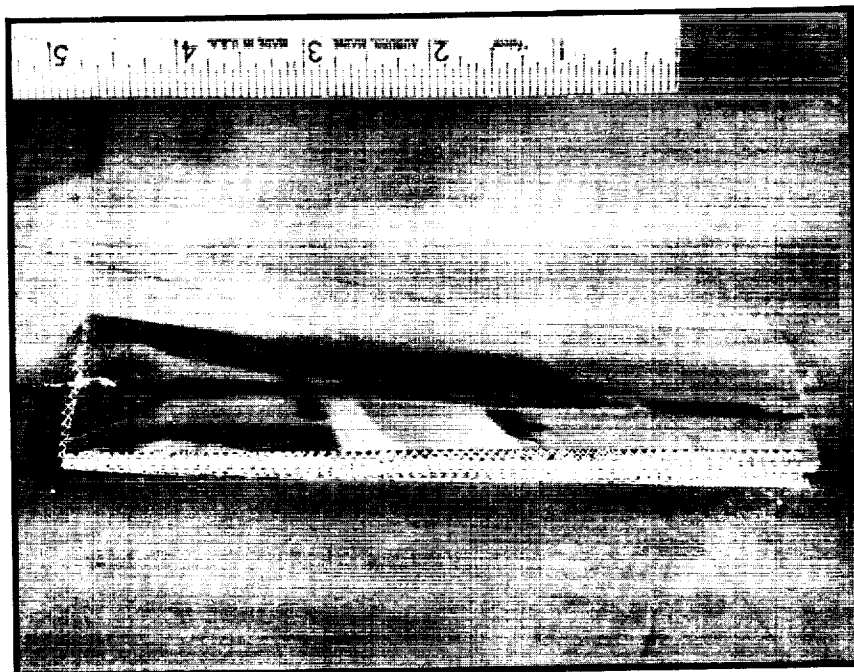


Figure 3. Unrolled Blanket Sample

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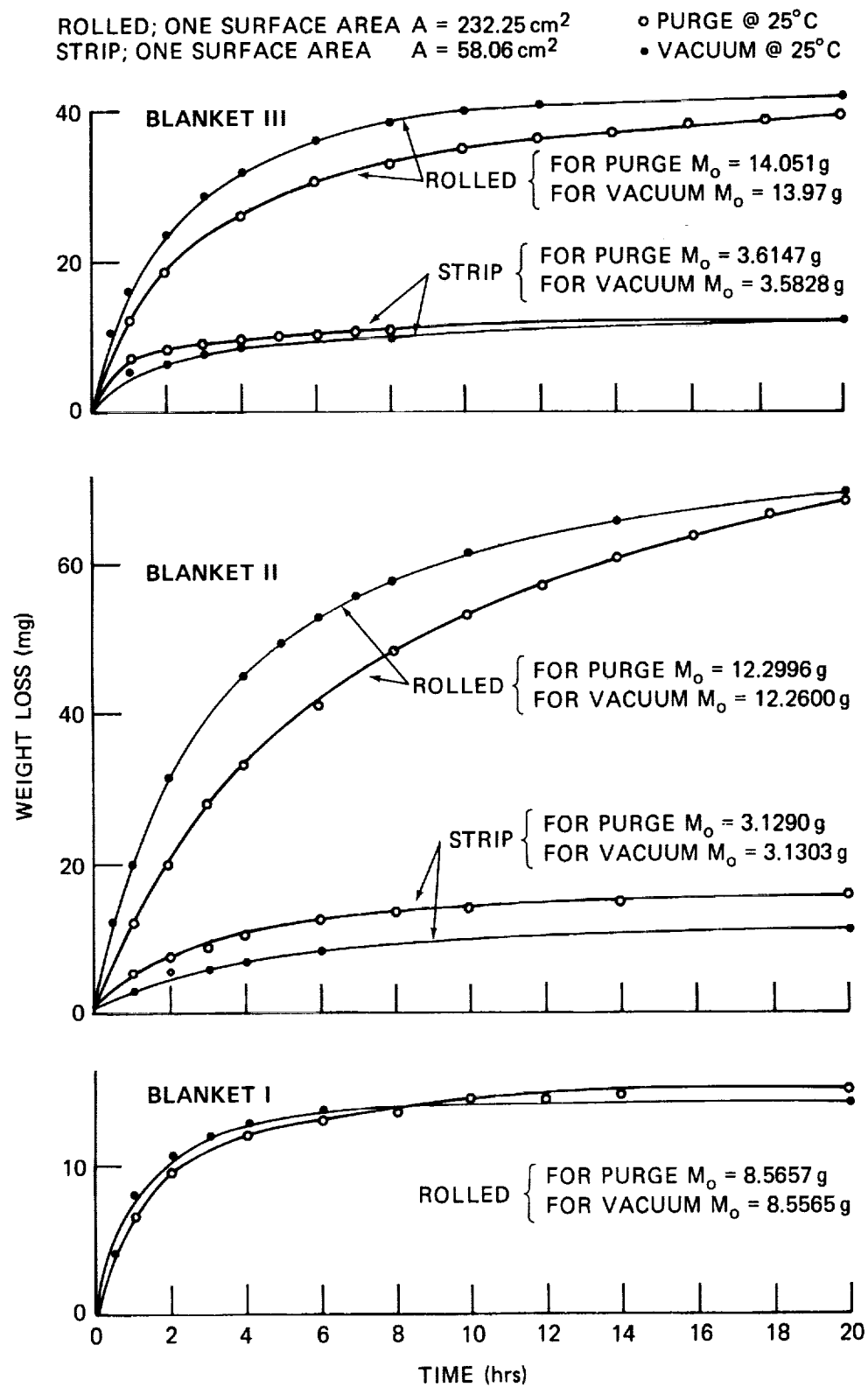


Figure 4. Blanket Samples Weight Losses Under Purge and/or Vacuum

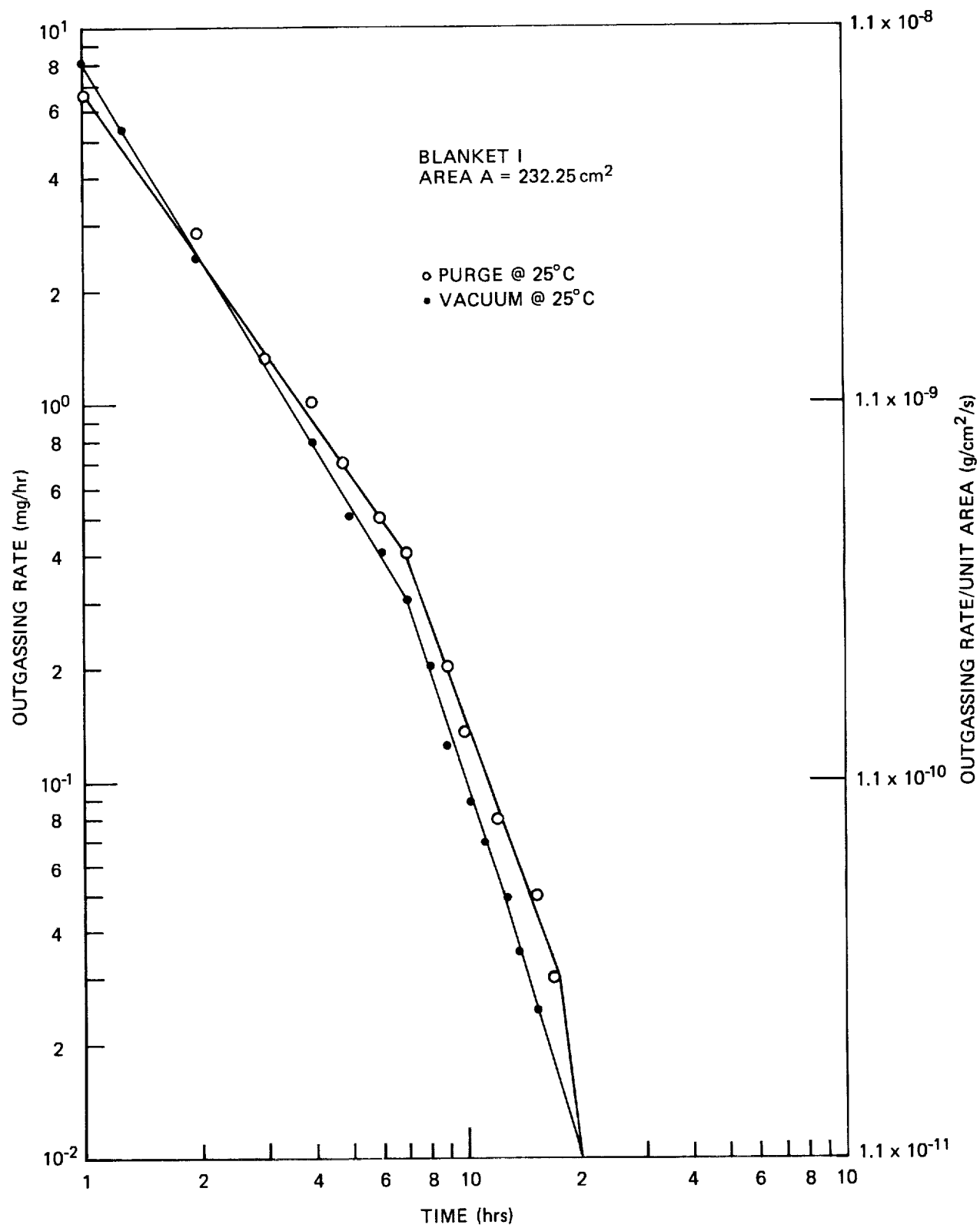


Figure 5. Outgassing Rates of Blanket I Obtained with Purging and with Vacuum Bake

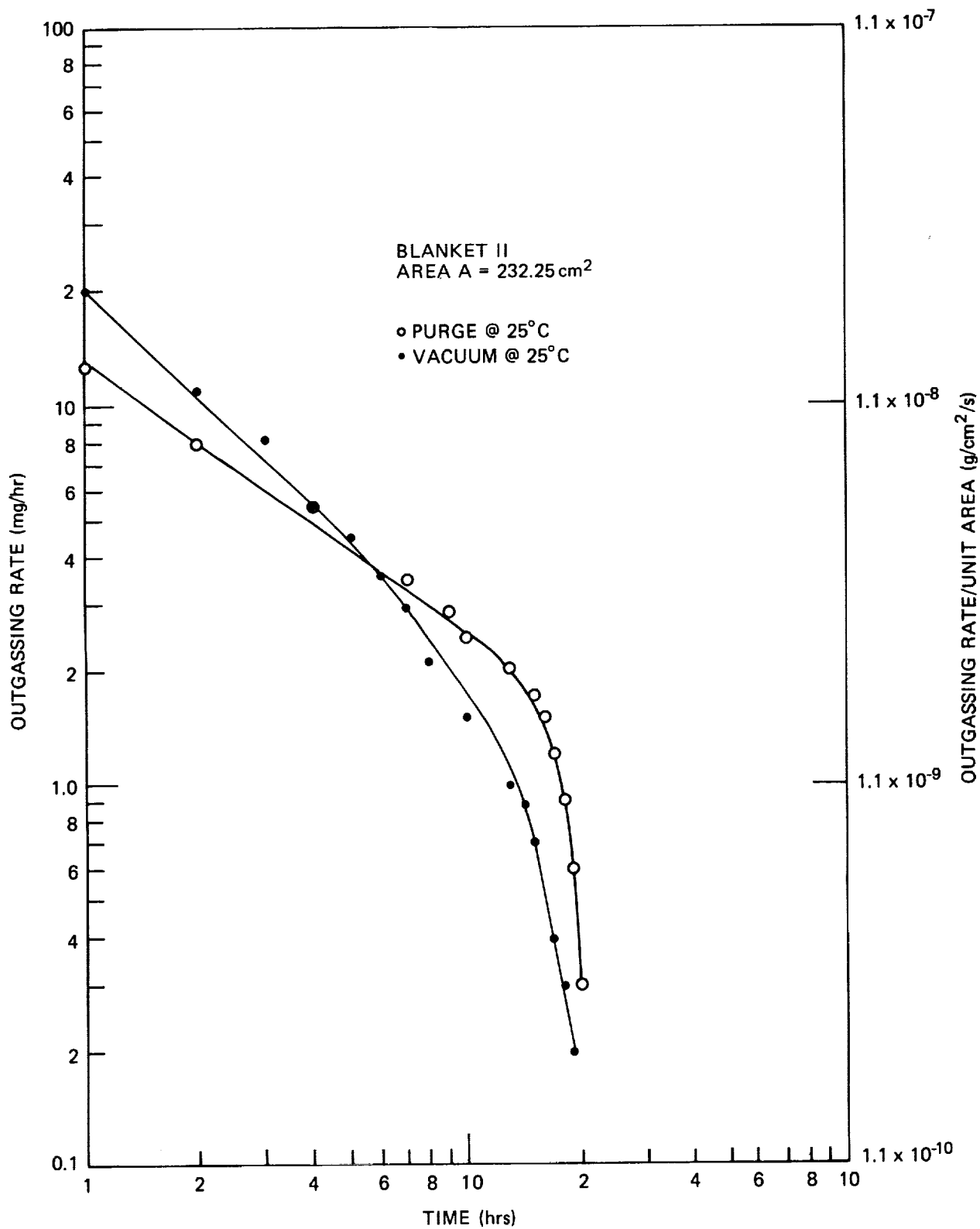


Figure 6. Outgassing Rates of Blanket II Obtained with Purging and with Vacuum Bake

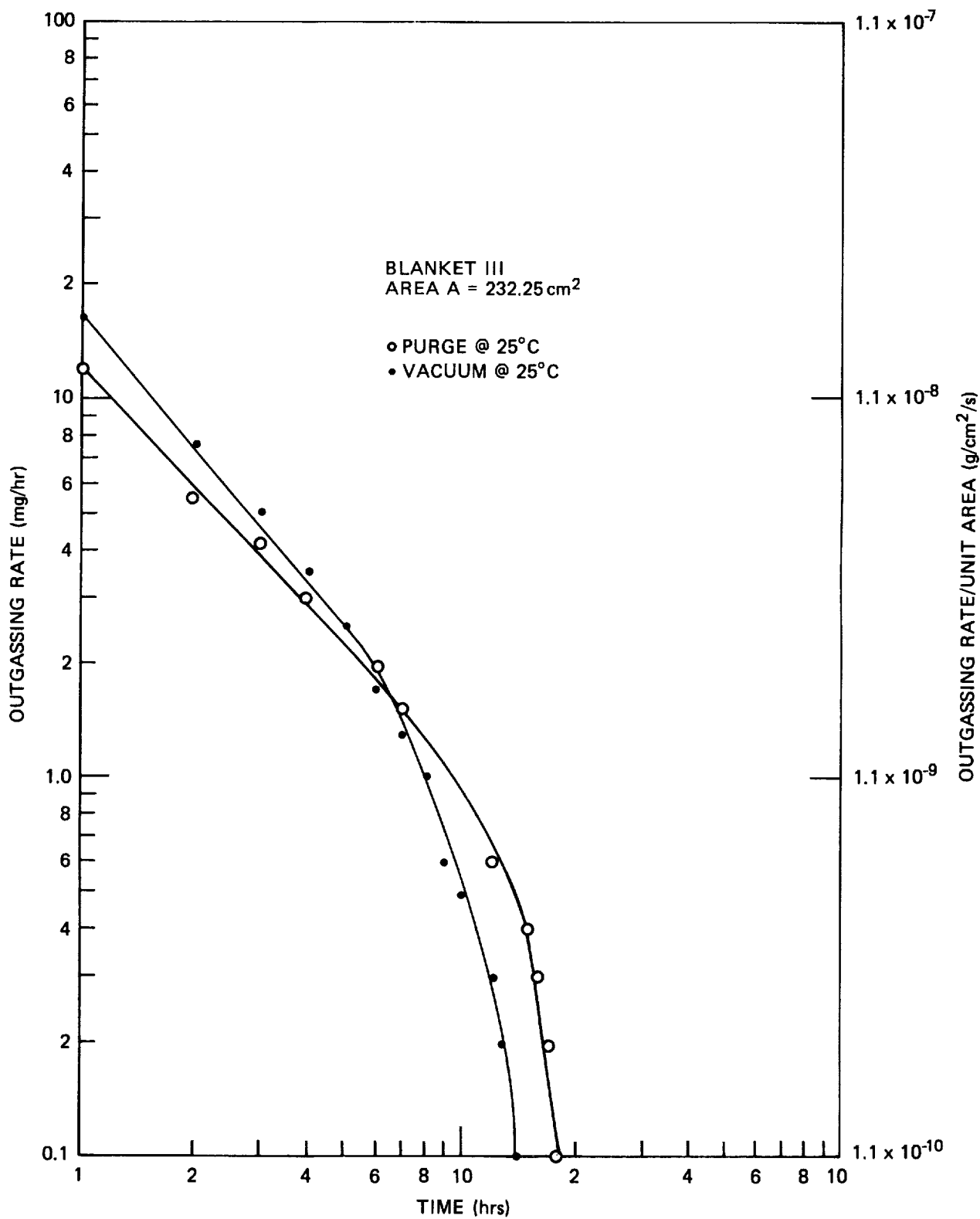


Figure 7. Outgassing Rates of Blanket III Obtained with Purging and with Vacuum Bake

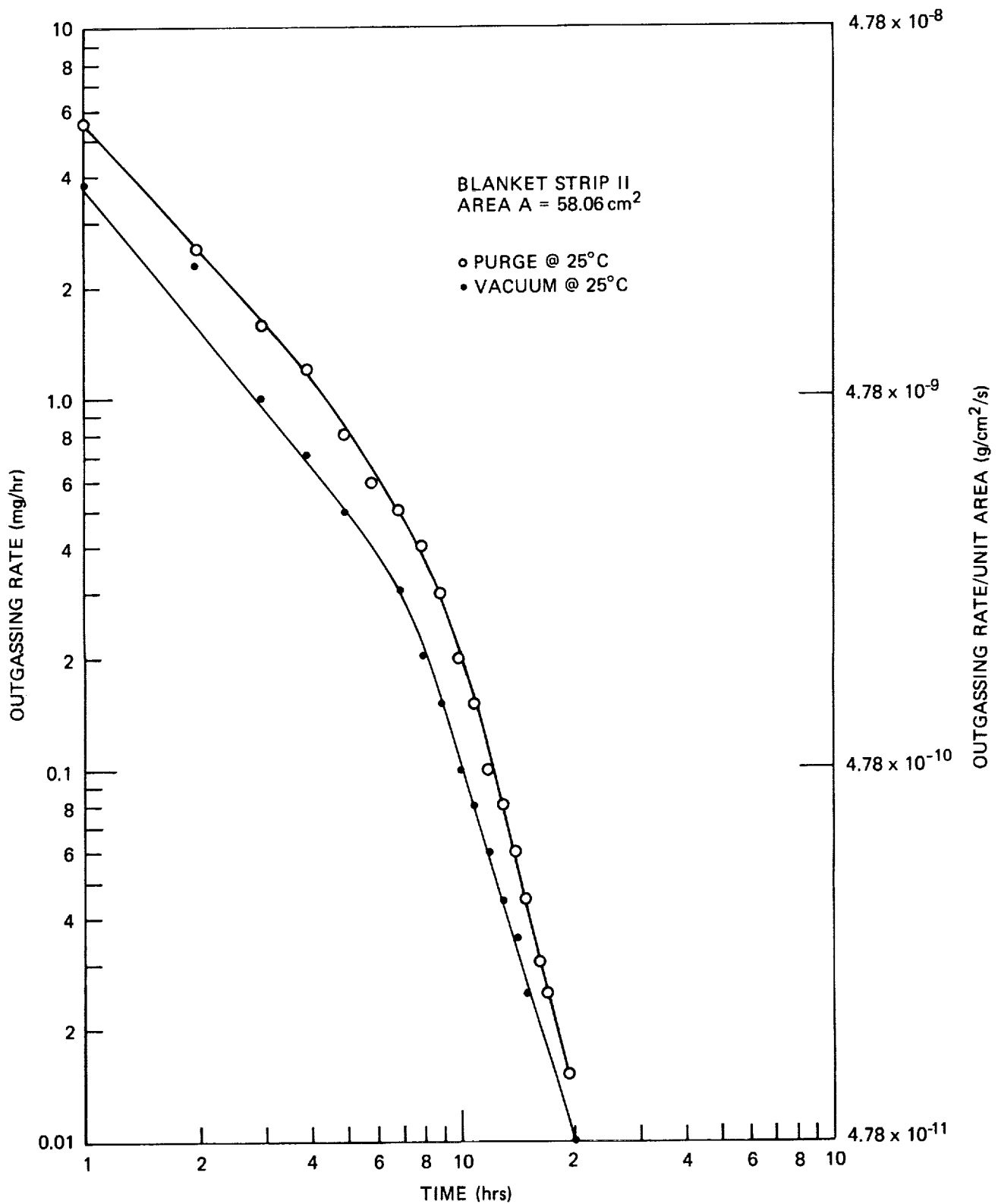


Figure 8. Outgassing Rates of Blanket II Unrolled Strip Obtained with Purging and with Vacuum Bake

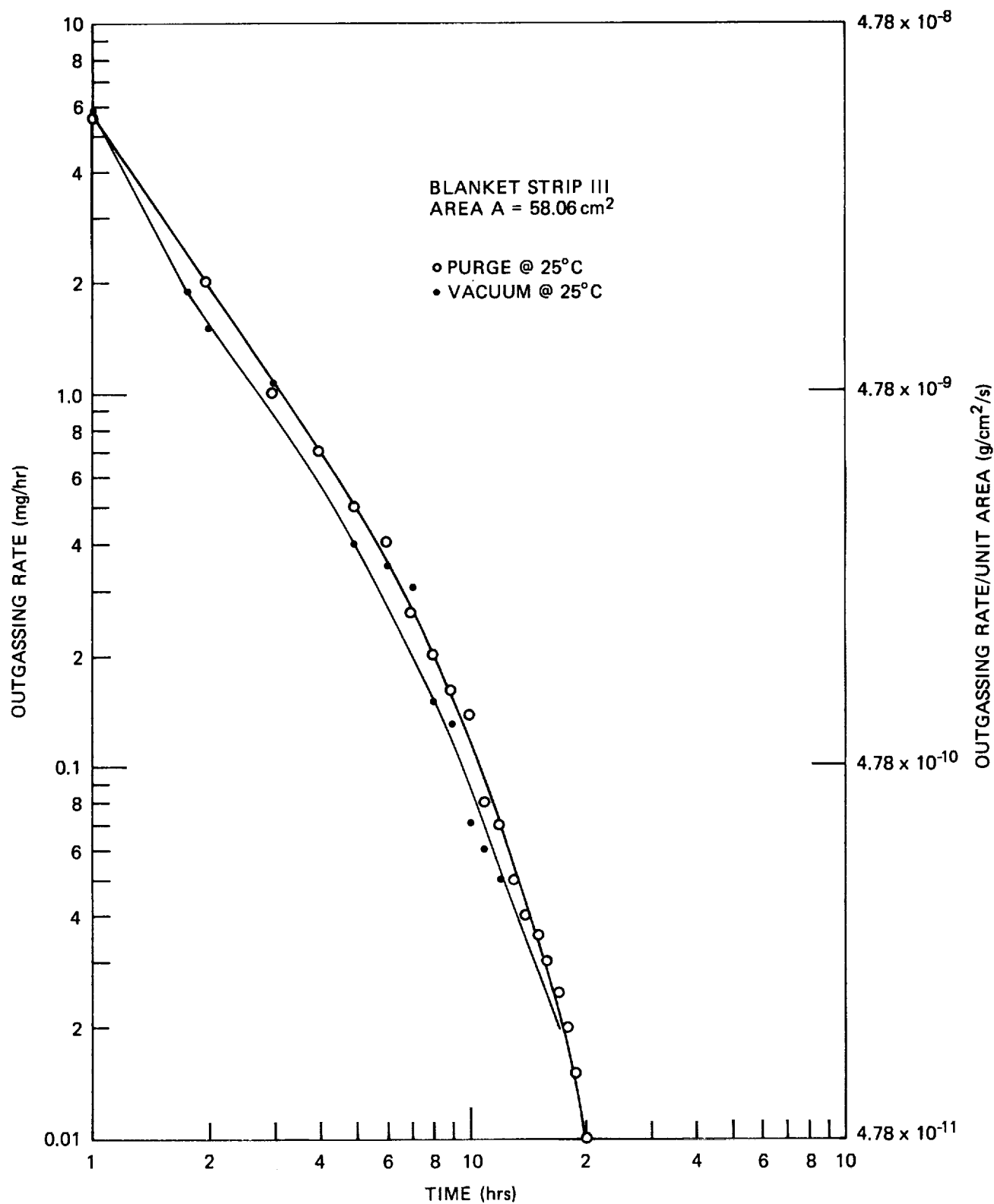
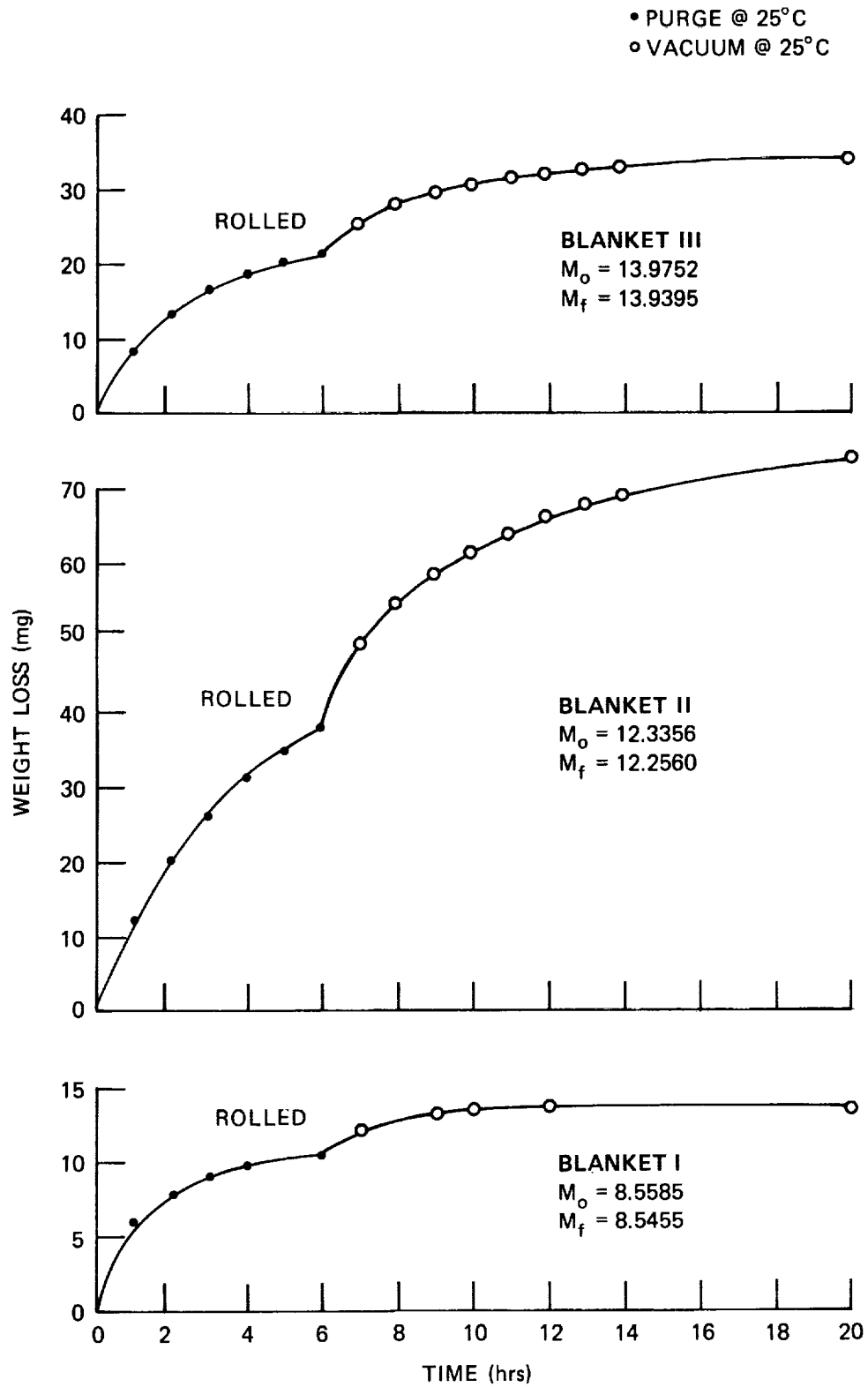


Figure 9. Outgassing Rates of Blanket III Unrolled Strip Obtained with Purging and with Vacuum Bake



BLANKET; ONE SURFACE AREA A = 232.25 cm²

Figure 10. Weight Losses of Blanket Samples: Purge Followed by Vacuum

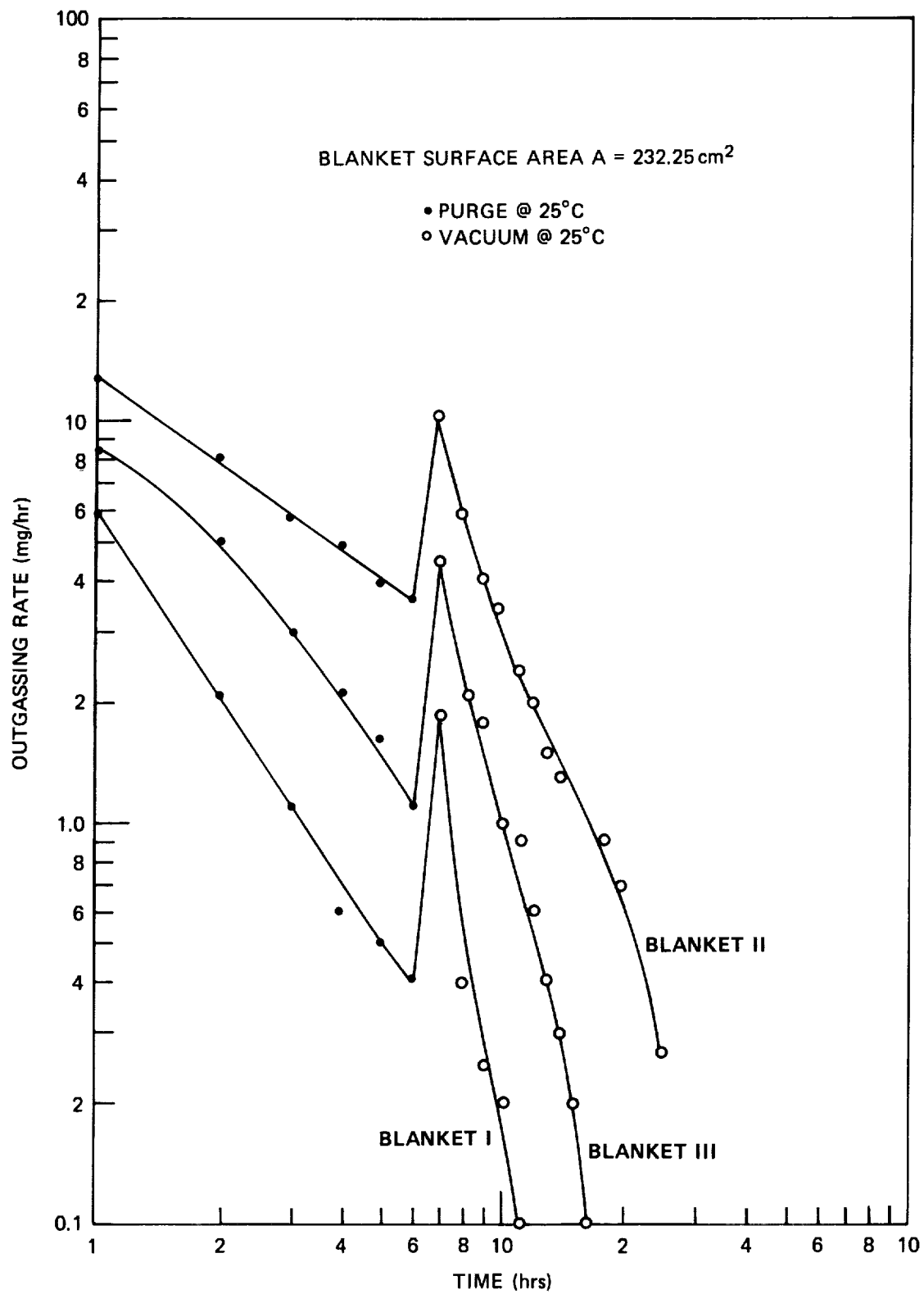


Figure 11. Outgassing Rates of Blankets in Vacuum After an Initial Purge

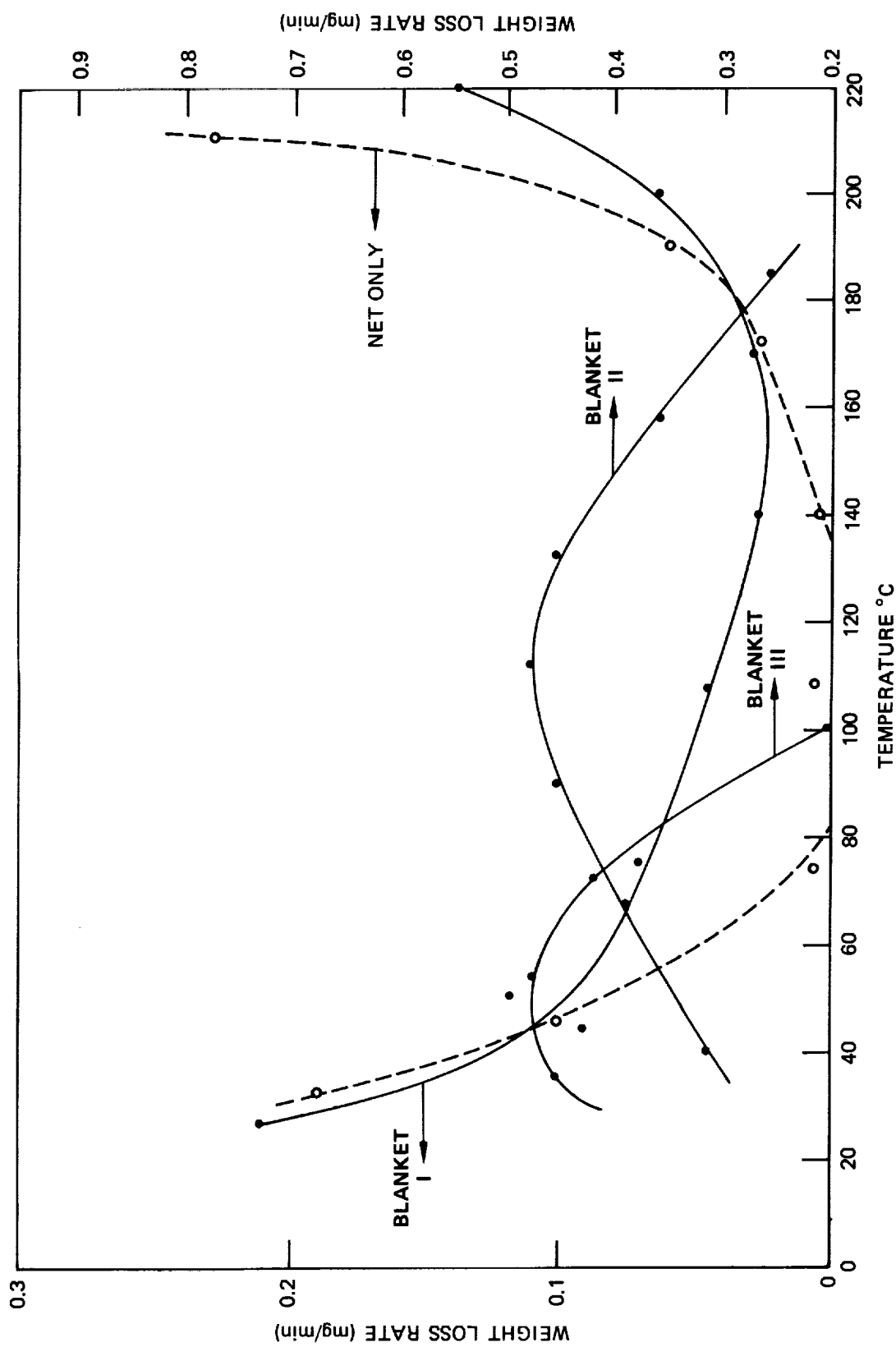


Figure 12. Weight Loss Rates Versus Blankets Temperatures

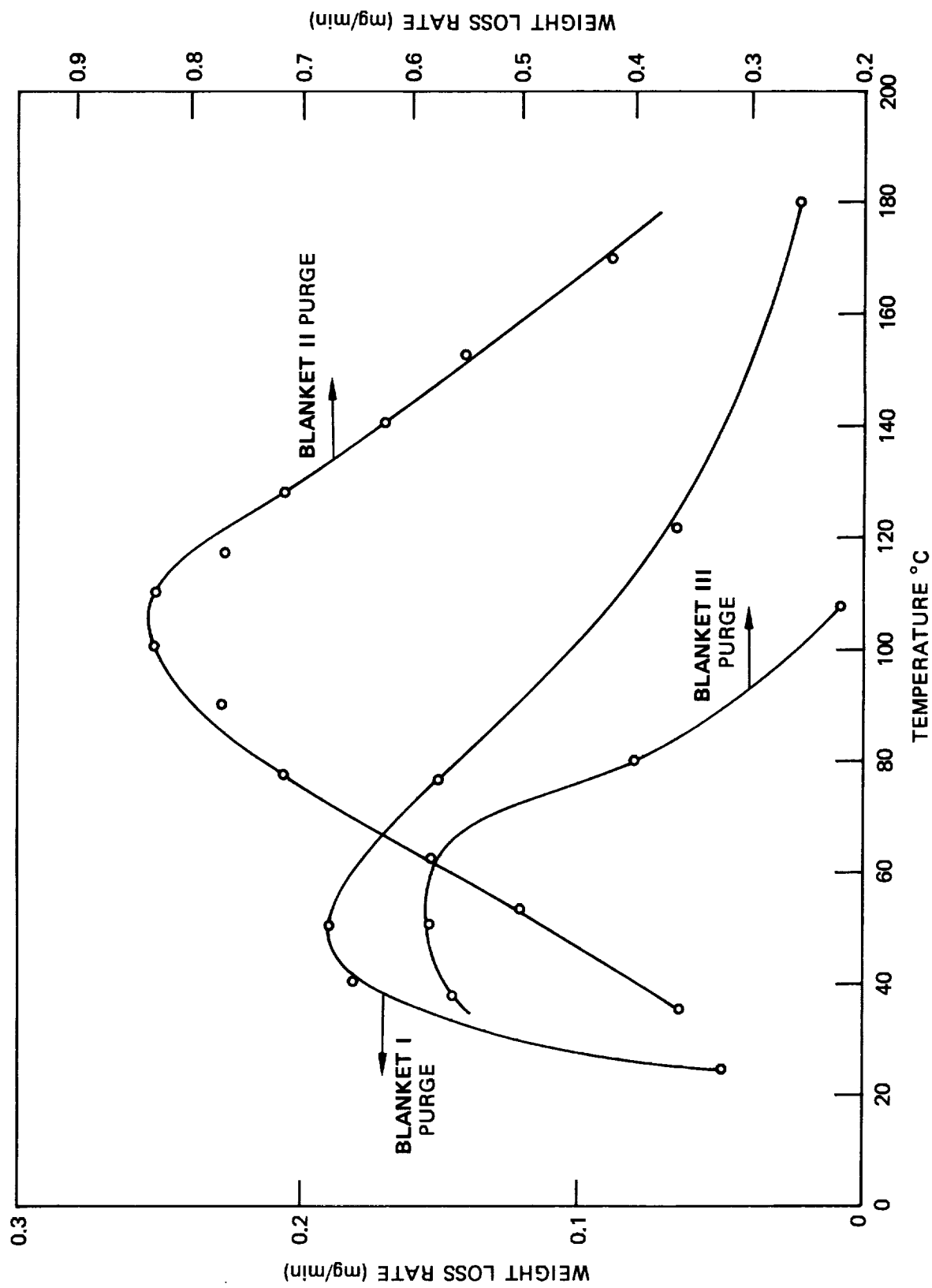


Figure 13. Weight Loss Rates Versus Purging Temperatures

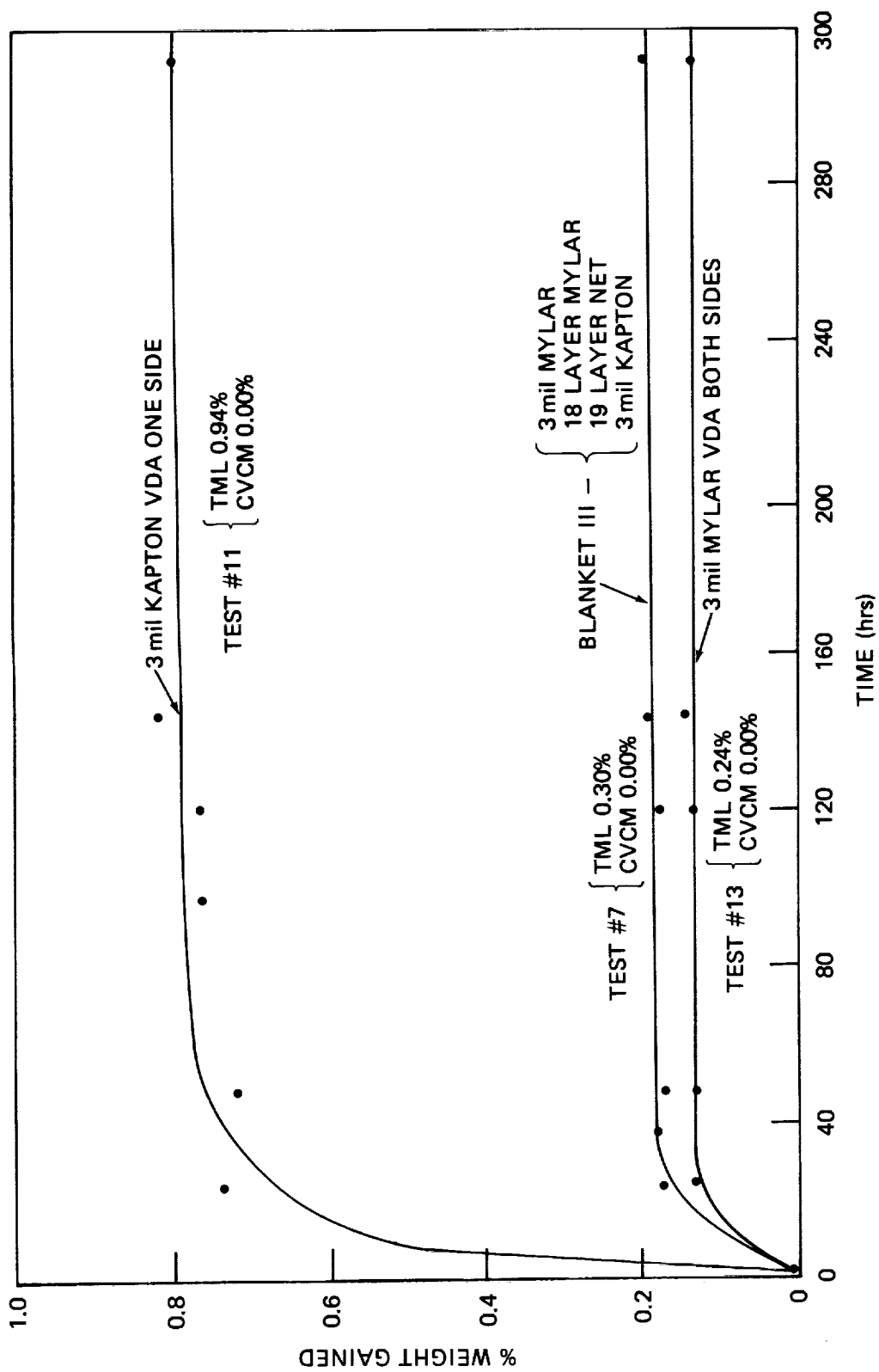


Figure 14. Percentage of Weight Regained Versus Time for Assembled Blanket III, for a Mylar Component, and for a Kapton Component

Report Documentation Page

1. Report No. NASA TM-100760		2. Government Accession No.		3. Recipient's Catalog No.	
4. Title and Subtitle Spacecraft Thermal Blanket Cleaning: Vacuum Bake or Gaseous Flow Purging				5. Report Date April 1990	
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16. Abstract Thermal blankets are used to protect surfaces of spacecraft and space instruments and to provide thermal control of the system they are covering. The blankets consist of layers of materials having highly reflective surfaces interposed by Dacron nets. The outer layers are, for protective reasons, thicker than the others and have surface coatings designed to reflect specific radiation wavelengths. These blankets are required to protect a satellite against electrons, protons, and ultraviolet radiation, and to be stable in the presence of atomic oxygen, moisture, and radiation. Materials used for these blankets are Kapton and Mylar which may be surface aluminized or gold coated. The mass losses and the outgassing rates per unit area of three thermal blankets consisting of various combinations of Kapton and Mylar were measured with a microbalance using two methods: vacuum bake and gaseous flow purging. The two methods have been compared for their effectiveness in cleaning the blankets for their use in space applications and the results are presented in this document.					
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